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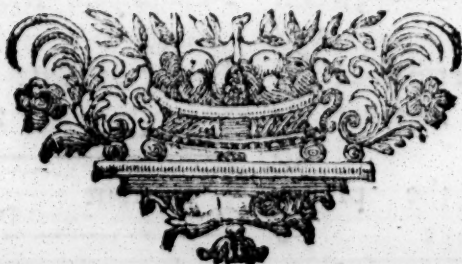
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A N
I N T R O D U C T I O N
T O T H E
T H E O R Y A N D U S E
O F T H E
P A N T O G R A P H E R ;

AS MADE AND IMPROVED BY
T H O M A S N E W M A N,
(Successor to Mess. HEATH and WING,)
Mathematical Instrument Maker in Exeter Change.

S H E W I N G

The Nature of its Construction, and the Manner of
using it in copying Drawings of Figures, Ornaments,
Plans, Maps, Charts, &c.

By S. D U N N,
Teacher of the Mathematical Sciences.

L O N D O N : M D C C L X X I V .





A N
I N T R O D U C T I O N
T O T H E
T H E O R Y A N D U S E
O F T H E
P A N T O G R A P H E R.

29.1.14.

I. *Whence the PANTOGRAPHER has its Name.*

✱✱ HIS instrument has its name from *παν* *all*, and *γραφω* *to describe*, and therefore PANTOGRAPHY is the art or science of describing things generally, but being understood here in a limited sense, is meant to be the art of copying drawings, which have been already made, and the doing of this to any larger, smaller, or an equal scale, as shall be required; the instrument itself, whereby such drawings are copied, being called the Pantographer, a name which also might, without impropriety, be given to the person who performs with it.

II. *Its Invention but of late Years.*

When or by whom this instrument was first invented, is not certainly known ; probably it was the invention of some ingenious mathematician about two centuries ago, since it was about that time, that *Guido Ubaldu*s, an Italian mathematician and nobleman, contrived a method of drawing the fourth part of an ellipsis mechanically, a method which, although confined to the description of a conic section only, was then looked on as a capital improvement in mechanical geometry, and gave birth to the instrument now called the elliptical compasses.

III. *The improved Manner in which it was made by Messrs. HEATH and WING.*

But whether the Pantographer was so early invented, or later, it is certain that its improvement, and the finished manner in which it is now made, has been owing to the ingenuity of later times ; and that, although the truth and certainty of its operations depend on geometrical principles, and the similarity of triangles in particular, a doctrine which was antiently known ; the mechanical formation of this instrument has been completed but a few years, by Messrs. *Heath* and *Wing*, Mathematical Instrument-Makers, late of the *Strand*, who also have first, and before any other person, added such farther improvements thereto, as are mentioned in this Tract.

IV. *The*

IV. *The Legs of the Pantographer described.*

The Pantographer is made either of wood or brass, and consists principally of four flat rulers, two long ones, and two shorter ones. The two longest rulers are called the two long legs, and are joined at their extremities by a joint about which they move as their centre; and the two shorter rulers are also joined, the end of one of them to a part of the long ruler or leg, near the middle thereof, where there is also a joint, about which it moves as its centre. The shorter rulers are sometimes called the shorter legs; and in like manner the other shorter ruler is joined to a part of the other long leg near its middle, about which it moves as its centre. Lastly, the other two ends of the shorter rulers, are joined by a joint, about which they move as a centre. So the instrument is a parallelogram (Fig. I.), as A E G H, with two of its sides as AE and AH produced to B and C respectively; the joints being at A, E, G, and H, and the additional lengths EB and HC for certain reasons described farther on.

V. *Where the Divisions and Numbers are placed.*

The parts of the instrument where the divisions or graduations are placed, are on the faces of the two shorter legs EG and HG; likewise on the additional parts of the long legs EB and HC; which divisions are, for the more convenient and expeditious setting of the instrument, so that it may copy any drawing, and imitate every part thereof in any greater or lesser proportion, as shall be required.

VI. *The Boxes, Fulcrum, and their Appendages.*

The two longer legs, and one of the shorter ones, have each of them a box with a thin or fiducial edge, which edge is for the readier and more exact fixing it to any of the divisions ; and these boxes are made to slide freely along the legs, and to fasten at any of the divisions by means of a screw. Also, at each of these boxes is an upright tube or hollow cylinder, to carry either a tracing pin, to trace out the original drawing with, or a lead pencil or port-crayon to draw the copy with, or to fix either to a moveable fulcrum, which is to be screwed to the edge of the table, or which is better, to a fulcrum of a sufficient weight for keeping the whole instrument steady, or rather opening and closing its joints properly, whilst this fulcrum is at dead rest on the table, and the instrument is moving round it as a centre ; for the more easy performance of which, the boxes and four principal joints, have small joints with rollers, and casters at their feet, by means of which they move with ease under all directions.

VII. *The Utility of the Instrument.*

The instrument being thus formed, and accurately made and graduated, becomes quite handy and convenient for all persons who are conversant in the art of drawing, and more particularly so to those who have either made but little progress in that art, or those who want to dispatch business of this kind with accuracy and expedition. For the

the outlines of any drawing whatsoever, and which are the principal difficulties to be overcome in copying of figures, ornaments, plans, maps, charts, &c. may hereby be had with the greatest readiness, and to any size or proportion, of either reduction or enlargement required; and the intermediate parts of the drawing may be filled up in the same manner; or if the performer chuses to do that finishing by the hand and eye, it may be so done, or as he shall best approve; which admirable property in this instrument, and its readiness in imitating all kinds of lines, however crooked or complex, cannot but deserve the highest encomiums. The principles on which the operations of this instrument depend, and on which its graduations are made, are as follows, viz.

VIII. *Construction of the Instrument.*

Let AEDF be a parallelogram, then are the opposite sides AE and DF equal to each other (Fig. 1.). And the opposite sides AF and ED are equal to each other. Produce the side AE at pleasure to *b* and B, &c. And produce the side AF at pleasure to H and C, &c. Also, produce the side ED, and compleat the parallelogram AEGH. Make AC equal to AB; and ED equal to EB. Draw the lines BDC and *bdC*, make *df* parallel to BA, and *af* parallel to *bd*. From which arises the following investigation. Because ED is parallel to AC, therefore the triangles *bEd* and *bAC* and *dfC*, will be similar to each other, and consequently their sides will be proportional. Therefore wherever the point *b* is in the line AB, and the line *bdC*

drawn as before mentioned, the lines bd and dC , will bear the same proportion to each other, as the lines Af and fC , and also as the Lines Aa and Ab . Hence it follows, that under the above circumstances, the parallelogram $AEDF$ is a rhombus, but the parallelograms $AEGH$ and $AEdf$ are rhomboides. And if the side AB be supposed to remain immoveable, whilst the side AC moves outward until the angle BAC becomes a right angle, and the parallelism of the lines is preserved during this motion; then, when the angle at A becomes a right angle, the angle bEd will become a right angle; the line bC will become equal to bM , and the line bd will become equal to bN , &c. And hence the construction of the Pantographer will arise.

IX. *Organical Motion of the Instrument.*

For let the sides AE and GE be supposed to be joined by a joint at E , the side EA and FA to be joined by a joint at A , and the sides EG and HG to be joined by a joint at G . And whilst the side AB remains, fixed, let the point C , in opening or closing the angle at A , be supposed to be carried outward to c , or inward to c , so will the point H come to b outwardly or inwardly, the point d will come to δ , and the angle δEd will be equal to the angle, bAH respectively, and therefore the similarity of triangles will still be preserved, under these and all other positions, whilst the legs of the instrument are in motion.

X. *Farther*

X. *Farther considered.*

X. The like consequences will follow, supposing b to be a fixed centre, about which, not only the side AB turns, whilst the angles EAH , and EGH , and AEG , and AHG , remain as they were before the beginning of the motion; or otherwise speaking, if, whilst that side is so turning round the centre b , the angles EAH , and EGH , and AEG , and AHG , are becoming less or greater. And the like similarity of triangles will follow, supposing the whole instrument to turn or revolve round the point d ; or otherwise supposing it to revolve round the point C , whilst the aforementioned angles of the parallelogram $AEGH$ either remain as they were, or are altering; which establishes this principle of the Pantographer, namely, if either of the three points b , d , or C , do remain fixed and invariable, the other two points respectively, will, under all directions, pass over spaces parallel to each other, and proportional to their distances from the centre of motion. From these principles, the truth and certainty of the operations by the Pantographer are evident; and therefore we proceed to shew the manner of dividing or graduating it, which is as follows.

XI. *Investigation*

XI. *Investigation of general Theorems for graduating the Instrument.*

The instrument being formed as before described; let the leg AB be opened until the point C comes to M, so that the legs MA and AB, may make right angles with each other, and the aforementioned similitude of triangles will still hold good. For in this case, the point *d* will be carried to N, and if NP be drawn parallel to EA, the magnitude of the drawing described by the point *d* or N, will be to the drawing described by the point C or M, as AP to AM. And therefore putting radius AM equal to 1,0000, &c. for the number of equal parts contained in the long leg AC; and EN equal to *n* for the number of the same kind of equal parts contained in EN (or Ed) a part of the shorter leg EG; it will be, As MP : PN :: EN : Eb. That is, when AE is half

AB, As $1 - n : \frac{1}{2} :: n : \frac{\frac{1}{2} \times n}{1 - n} = Eb$. And Eb + AE, that is $\frac{\frac{1}{2} \times n}{1 - n} + \frac{1}{2} = Ab$. Which equation being reduced gives $\frac{1}{2 - 2n} = Ab$. And hence the follow-

ing tables were calculated both for vulgar fractions for the reduction of drawings from $\frac{1}{12}$ to $\frac{1}{2}$ of the original, and also the other Tables for reduction of drawings from $\frac{1}{100}$ to $\frac{1}{2}$, to each hundredth part of the radius; and by proportioning the differences between the hundredths, this second Table may be carried to thousandths of the radius.

XII. *Two*

XII. *Two TABLES for laying down Divisions on the Instrument.*

T A B L E I.

Shewing the Number of decimal parts of the radius AB, to be set off from A towards B, on the long leg of the Pantographer, to answer each aliquot part of the radius AC, &c.

	One.	Two.	Three.	Four.	Five.	Six.
For One Twelfth of AC	,5454	,6000	,6660	,7500	,8571	1,0000
One-Eleventh of AC	,5500	,6111	,6875	,7857	,9166	
One-Tenth of AC	,5555	,6250	,7143	,8333	1,0000	
One-Ninth of AC	,5625	,6429	,7500	,9000		
One-Eighth of AC	,5714	,6666	,4706	1,0000		
One-Seventh of AC	,5833	,7000	,8750			
One-Sixth of AC	,6000	,7500	1,0000			
One-Fifth of AC	,6250	,8333				
One-Fourth of AC	,6666	1,0000				
One-Third of AC	,7500					
One Half of AC	1,0000					

In this Table the first column is for $\frac{1}{12}$, $\frac{1}{11}$, $\frac{1}{10}$, &c. the second for $\frac{2}{12}$, $\frac{2}{11}$, $\frac{2}{10}$, &c. the third for $\frac{3}{12}$, $\frac{3}{11}$, $\frac{3}{10}$, &c. the fourth for $\frac{4}{12}$, $\frac{4}{11}$, $\frac{4}{10}$, &c. the fifth column for $\frac{5}{12}$, $\frac{5}{11}$, &c. of the original drawing.

T A B L E II.

Shewing the number of decimal parts of the radius AB, to be set off from A towards B, on the long leg of the Pantographer, to each hundredth part of the radius AC with the differences for proportioning to thousands, &c.

Tenths.	0 100ths	1 100ths	2 100ths	3 100ths	4 100ths	5 100ths	6 100ths	7 100ths	8 100ths	9 100ths	10 100ths	Tenths.
0	,5000 differ.	,5050 50	,5102 52	,5154 52	,5208 54	,5263 55	,5319 56	,5376 57	,5434 58	,5494 60	,5555 61	9
1	,5555 differ.	,5618 63	,5682 64	,5747 65	,5814 67	,5882 68	,5952 70	,6024 72	,6097 73	,6173 76	,6250 77	8
2	,6250 differ.	,6329 79	,6410 81	,6493 83	,6579 86	,6666 87	,6757 91	,6849 92	,6944 95	,7042 98	,7143 101	7
3	,7143 differ.	,7246 103	,7353 107	,7463 110	,7576 113	,7693 117	,7813 120	,7936 123	,8064 128	,8197 133	,8333 136	6
4	,8333 differ.	,8474 141	,8620 146	,8772 152	,8929 157	,9091 162	,9259 168	,9434 175	,9615 181	,9804 189	1,0000 196	5
	10 100ths	9 100ths	8 100ths	7 100ths	6 100ths	5 100ths	4 100ths	3 100ths	2 100ths	1 100ths	0 100ths	

XIII. *Why the Fractional Numbers are placed at their corresponding Graduations.*

From what has been already proved, it is evident that if the length of $\frac{1}{12}$, $\frac{1}{11}$, $\frac{1}{10}$, &c. to $\frac{1}{3}$ and $\frac{1}{2}$ of the radius AC. be set off from E towards D, and those respective fractions, in Table I. are there written, and also that the correspondent decimal parts of the radius AB, be set off from A towards B, and there those very same respective fractions $\frac{1}{12}$, $\frac{1}{11}$, $\frac{1}{10}$, &c. to $\frac{1}{3}$ and $\frac{1}{2}$, are also written, that this will graduate or divide one part of the Pantograph, and make it fit to be used for those reductions respectively. Also, it is evident, that if the Numbers answering to any other of the fractions which are less than half of unity or 1, are in like Manner inserted by Table I.; or farther, if the more minute divisions and subdivisions to the hundredths or thousandths parts, be inserted in like manner from Table II, the instrument may be readily and accurately set off for such a reduction, and the drawing may be made agreeable thereto.

XIV. *The Manner of reducing a Drawing in any given Proportion, shewn by a general Example.*

Suppose, for instance, the Pantograph was to be set for reducing a drawing to a fourth part of its original size. Put the fulcrum at $\frac{1}{4}$ in the leg EB, the pencil at $\frac{1}{4}$ in the leg EG, and the tracer at C, and the instrument is fit for use. Otherwise, put the fulcrum at $\frac{1}{4}$ in the leg EG, the pencil at $\frac{1}{4}$ in the leg AB, and the tracer at C. And the like method is to be observed for any other proportion, provided it doth not amount to more than half, that is, provided the original drawing is not to be less than double the reduced one; for
in

in such case, whether the fulcrum be at *b*, whilst the pencil is at *d*, or whether the fulcrum be at *d* and the pencil at *b*, whilst the tracer is put at *C*, the pencil can never describe a drawing greater than half the dimensions of the original. And therefore, if a greater dimension than half the original drawing is required, then the fulcrum is to be removed to *C*, the tracer to *b*, and the pencil to *d*. And therefore, in numbering the graduations or divisions on the instrument, by writing the complemental numbers or remainders to unity of $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. to $\frac{1}{11}$, $\frac{1}{12}$, namely, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, to $\frac{10}{11}$, $\frac{11}{12}$, I say, by means of those Numbers written at the same divisions on the instrument, and the instrument being set or adjusted to them, and working it, the copy is made according to the reduction required.

XV. *The Manner of enlarging a Drawing by the Instrument, in any Proportion given.*

Hitherto, in this Tract, it has been shewn only how to reduce or lessen the original drawing, but it may sometimes happen, that a drawing is wanted larger than the original in a certain proportion assigned, which the instrument will readily effect if the following method be observed, viz. the tracer being in the leg *AB*, the fulcrum in *ED*, and the pencil at *C*, enlarges the picture, by the reverse of the fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. that is to say, it makes it twice as large at $\frac{1}{2}$, thrice as large at $\frac{1}{3}$, four times at $\frac{1}{4}$, &c. to ten times, eleven times, twelve times, &c. the dimensions of the original drawing. And therefore, if the complemental numbers in Table II, be applied, it may be enlarged, to $\frac{1}{10}$, $10\frac{1}{10}$, &c. times the dimensions of the original drawing, with the greatest exactness possible.

possible. A more practical account of the use of the instrument, is as follows :

XVI. General Directions for working the Instrument, and reducing or enlarging a Drawing in any Proportion assigned.

The numbers in Table I, being put on the leg ZB and ZD, Fig. 1 and 2, and those in Table II, being put on the legs XC and XE, and a filken thread running through the pins at the joints, and fastened to the lead pencil in the tracing tube, for the lifting it up above the paper whilst it is not in use; set the thin or fiducial edges of the boxes B and D to the numbers expressing the proportion of the copy to the original, there screw them fast, and in like manner the edge of the box A to the line C. In which case note, that if the copy is to be $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. of the size of the original, B is the fulcrum, C the tracer out of the original, and D the pencil making the copy. But if the copy is to be more than half, as $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, &c. of the size of the original, then C is the fulcrum, B the original, and D the Pencil making the copy. And farther, if the copy is to be twice, three times, or four times, the size of the original, then B is the fulcrum, D the tracer out of the original, and C the pencil making the copy, and this is the first or more cursory way of using the Instrument, and is applicable for reductions to $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, &c. also $\frac{2}{3}$, $\frac{3}{4}$, $\frac{4}{5}$, &c. likewise for enlargements by 2, 3, 4, &c. times respectively,

XVII. The same continued to the Hundredth or Thousandth Part of the Dimensions of the Original.

But if you would reduce the original to $\frac{1}{100}$, or to $\frac{1}{1000}$ or any decimal part of the size it is

is given in, then, the numbers are to be sought on the legs AC and XE, and for any reduction to less than half the size of the original, C is to be the fulcrum, B the tracer out of the original, and E the pencil making the copy, this serves for all numbers from $\frac{1}{10}$ to $\frac{1}{5}$. But for numbers between $\frac{1}{10}$ and $\frac{1}{5}$, B is to be the fulcrum, C the original, and E the pencil making the copy.

XVIII. *The small Delineations in the Plate, described, with their Use.*

A more particular description of the several parts of the Pantographer delineated in the plate hereunto annexed, is as follows. Fig. 1. shews the outlines of the instrument and its divisions. Fig. 2. shews the manner in which the instrument performs organically, by an example in reducing a picture, the fulcrum being at B, the tracer at C, and the pencil at D, from which, and what has been herein before proved, the copy of this picture is less than half the size of the original. Fig. 4. has been more particularly explained by Fig. I. P represents the moveable fulcrum. I the cylinder thereof. R a collar. E the tracing pin. A one of the boxes. H the cup over the pencil or port-crayon, into which may be put small shot or sand if the artist is desirous of having the lines of the copy strongly defined. F the tube for carrying the pencil. B another box. L a small wheel or castor, which has a double slit or groove x and y , to be fixed to the leg SB by the groove x , when the pencil is put into the box B. But when the pencil is put into the box D, the castor L slips on the leg D by the groove y . M, a wheel or castor to be put on the leg A, &c.

FINIS.



29.1.14.

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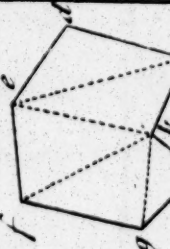
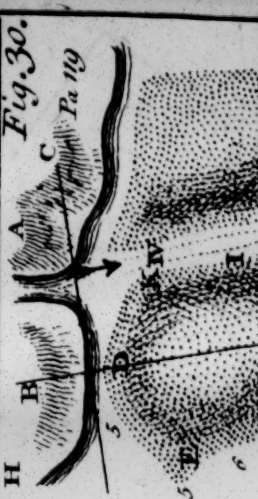
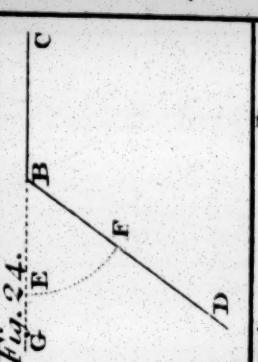
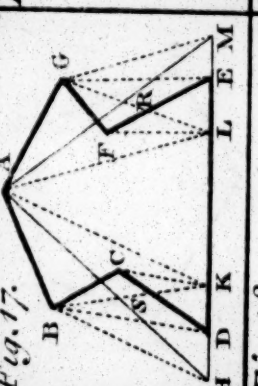
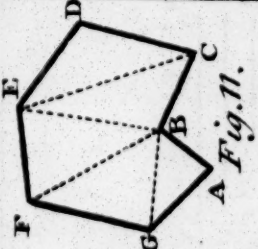
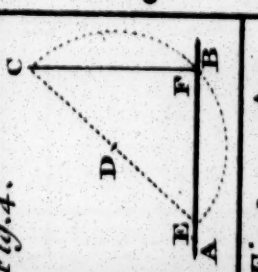
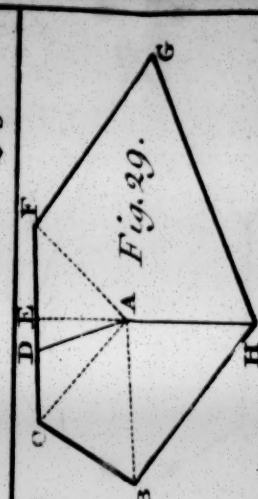
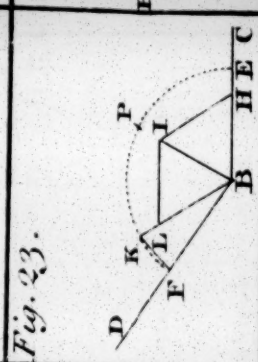
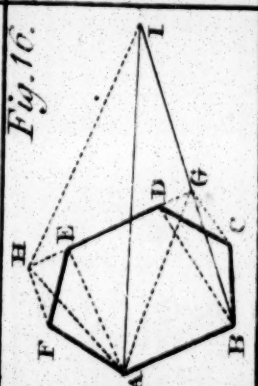
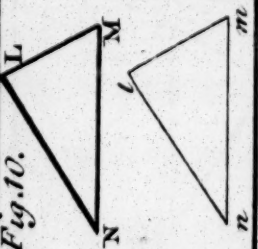
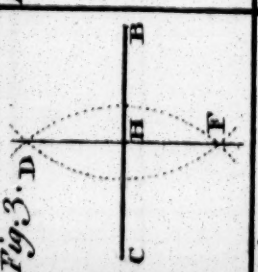
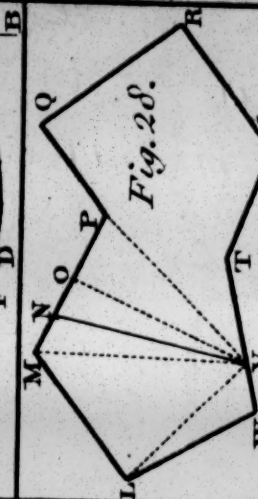
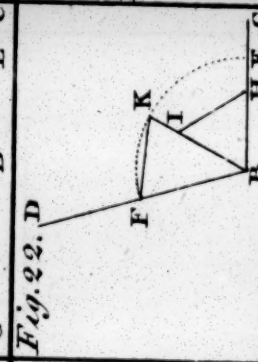
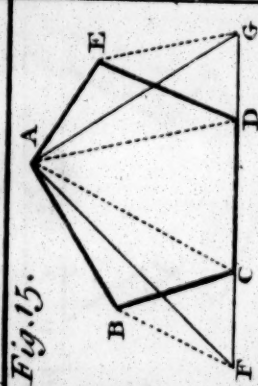
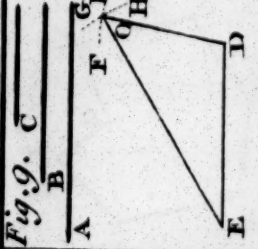
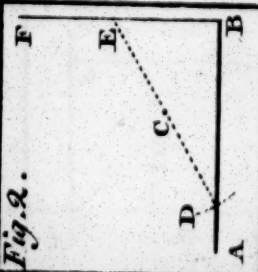
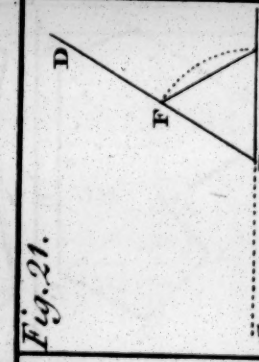
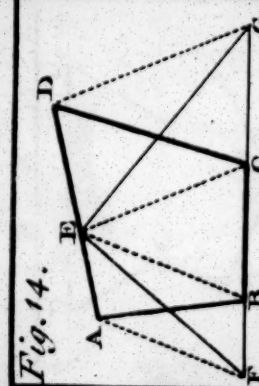




Fig. 6.

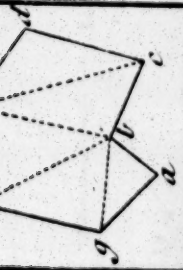


Fig. 12.

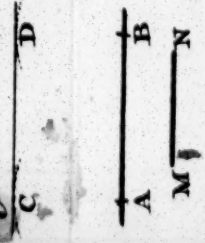
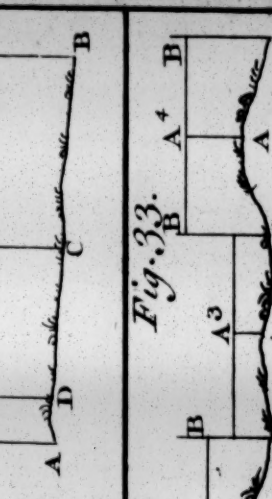
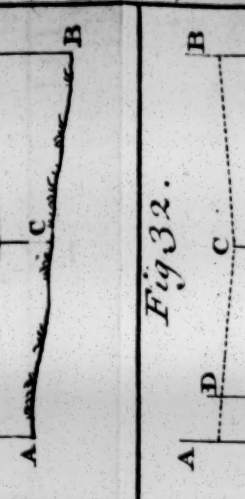
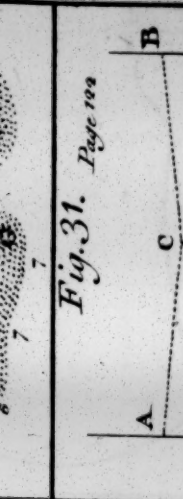
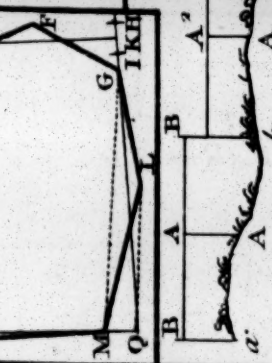
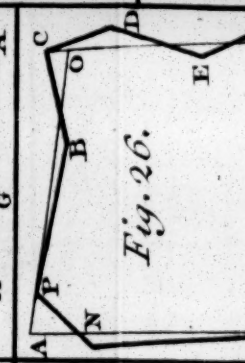
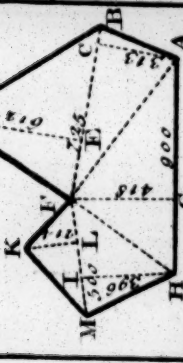
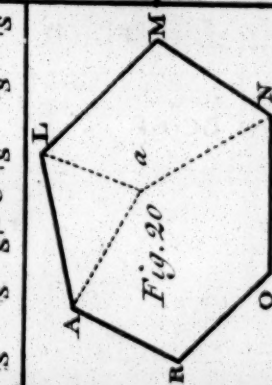
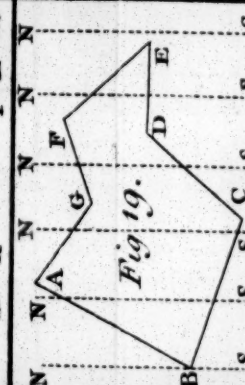
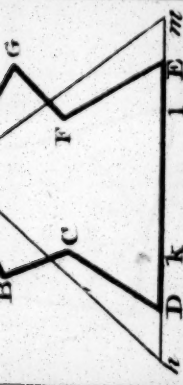
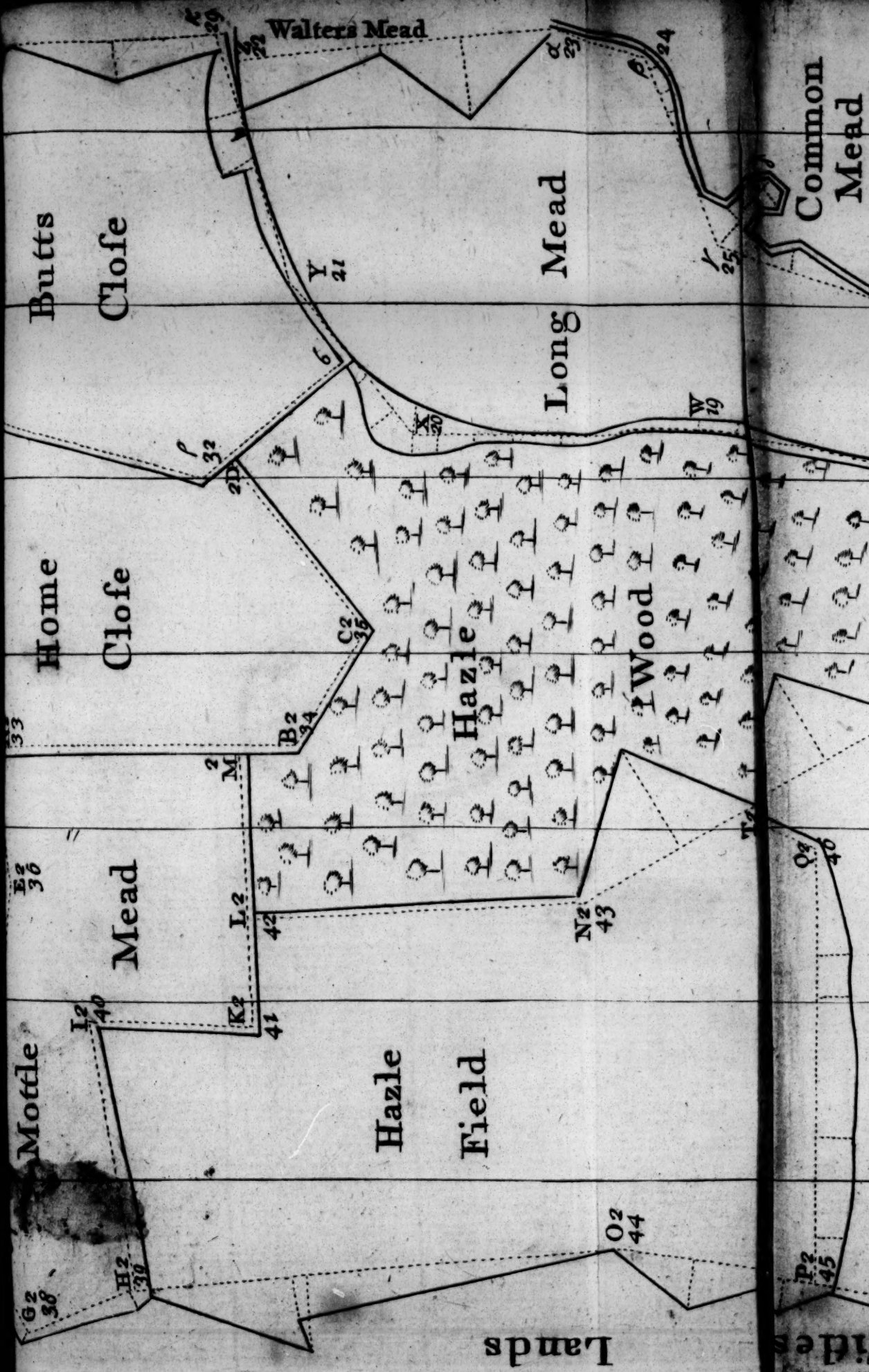
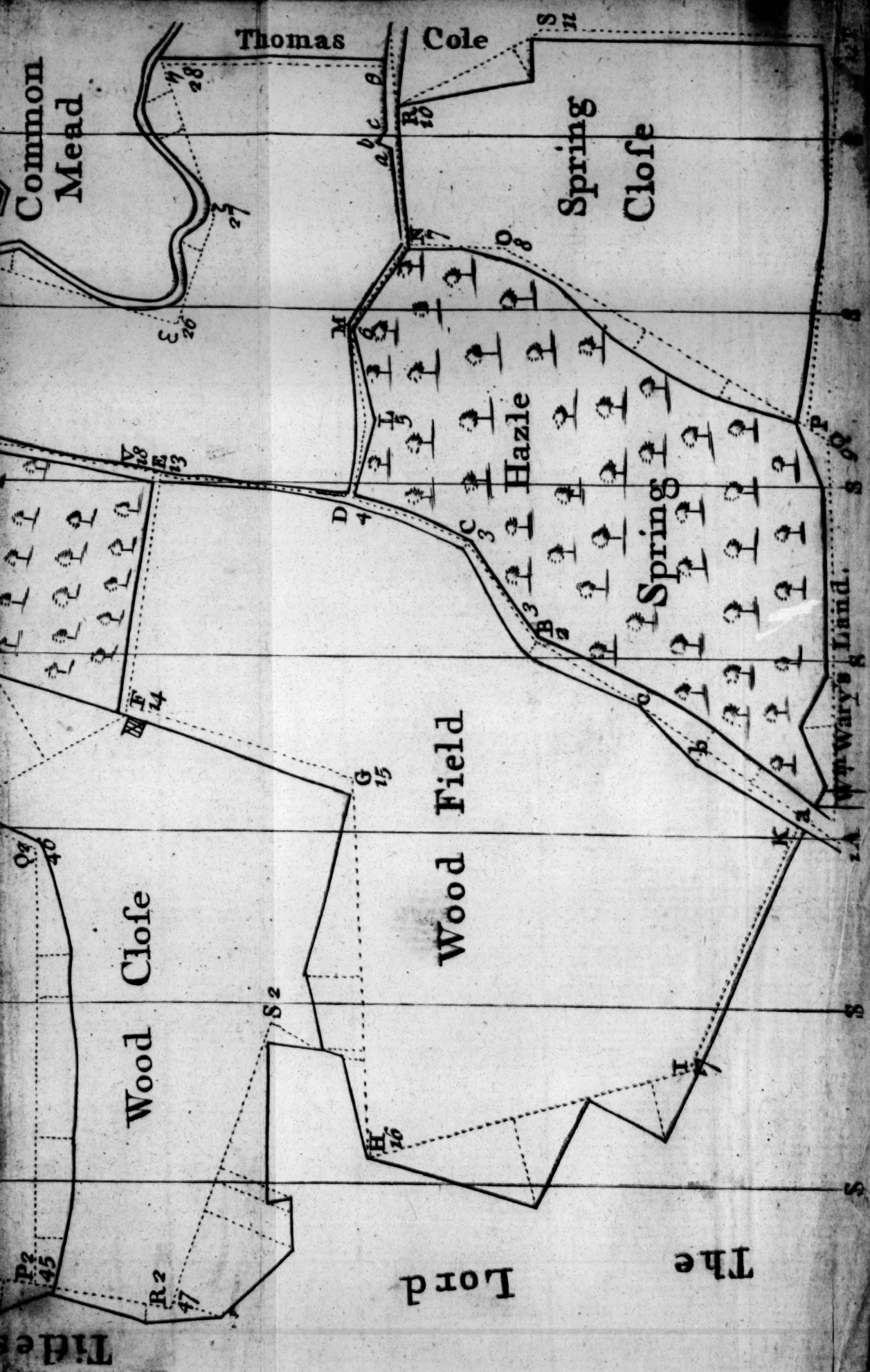
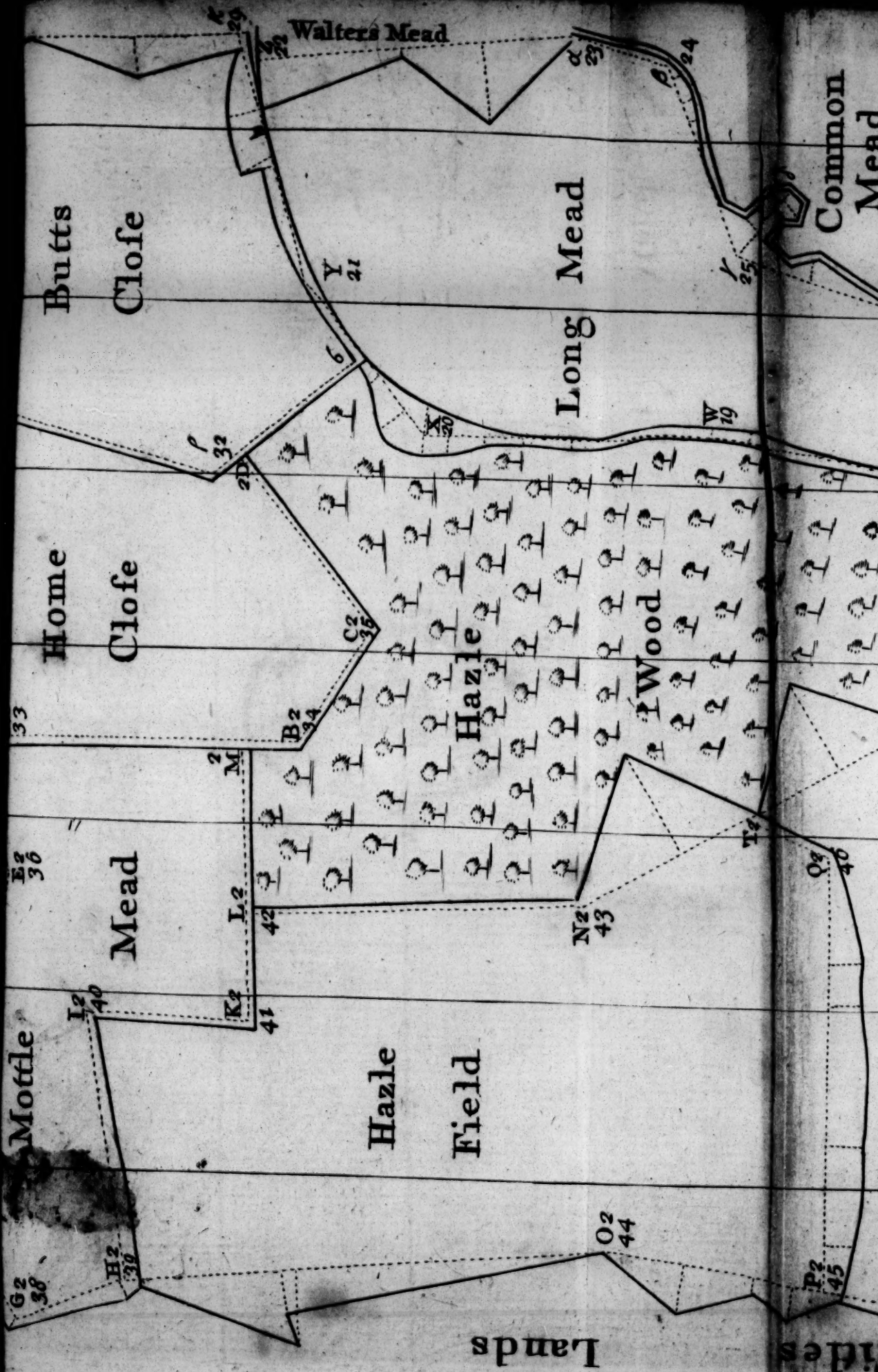


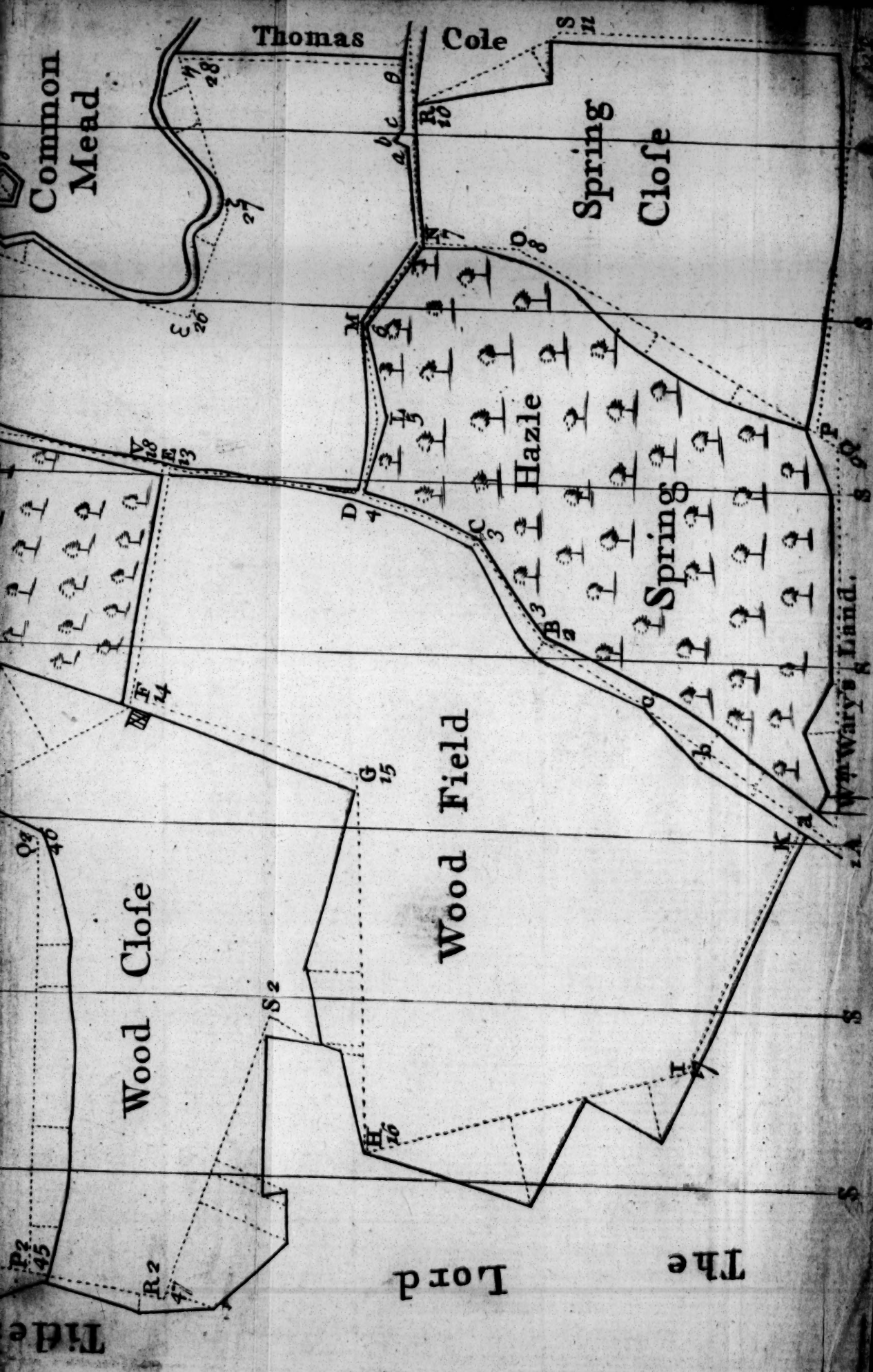
Fig. 13.











Common
Mead

Thomas

Cole

Spring
Clofe

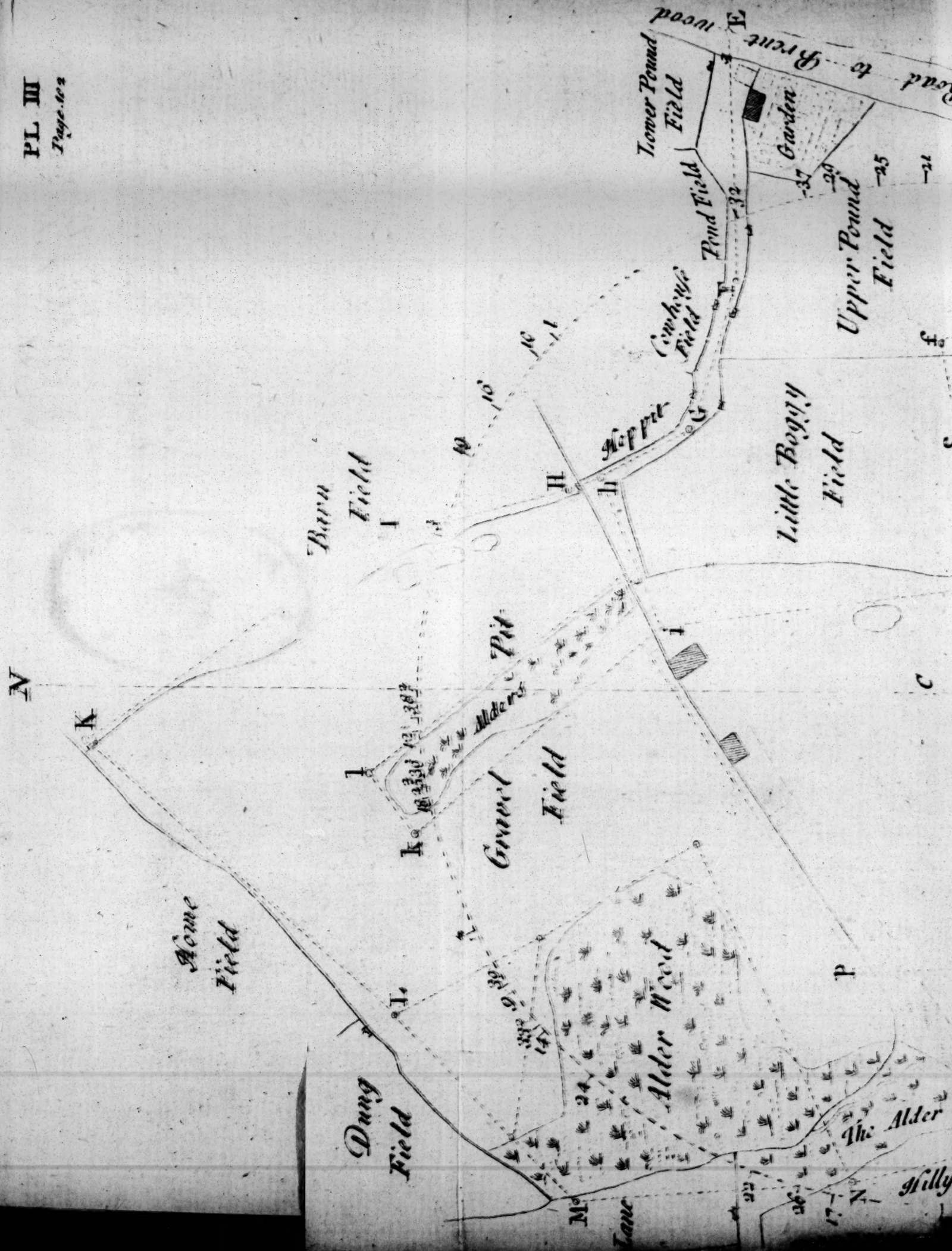
Hazel

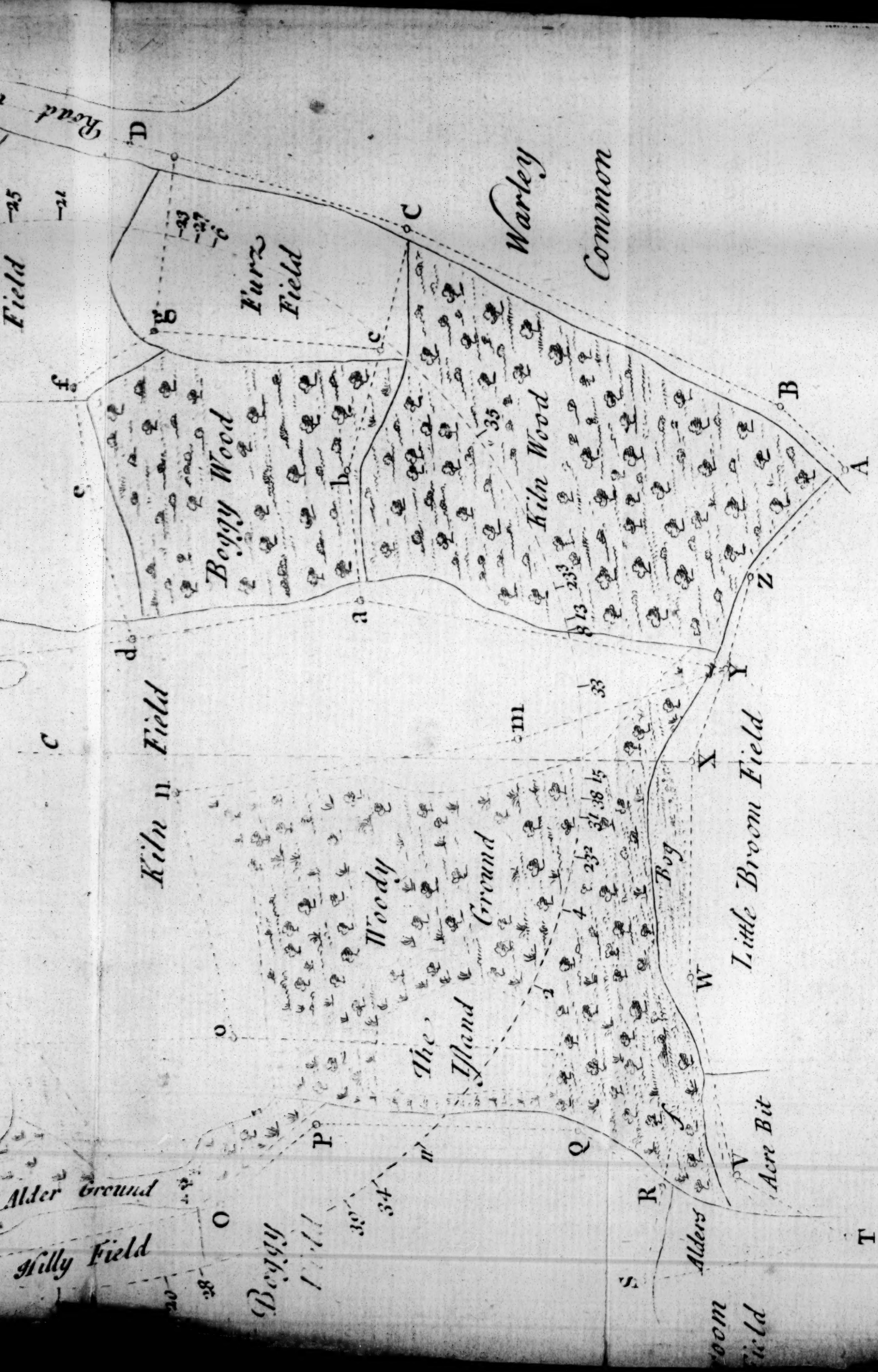
Wood Field

Wood Clofe

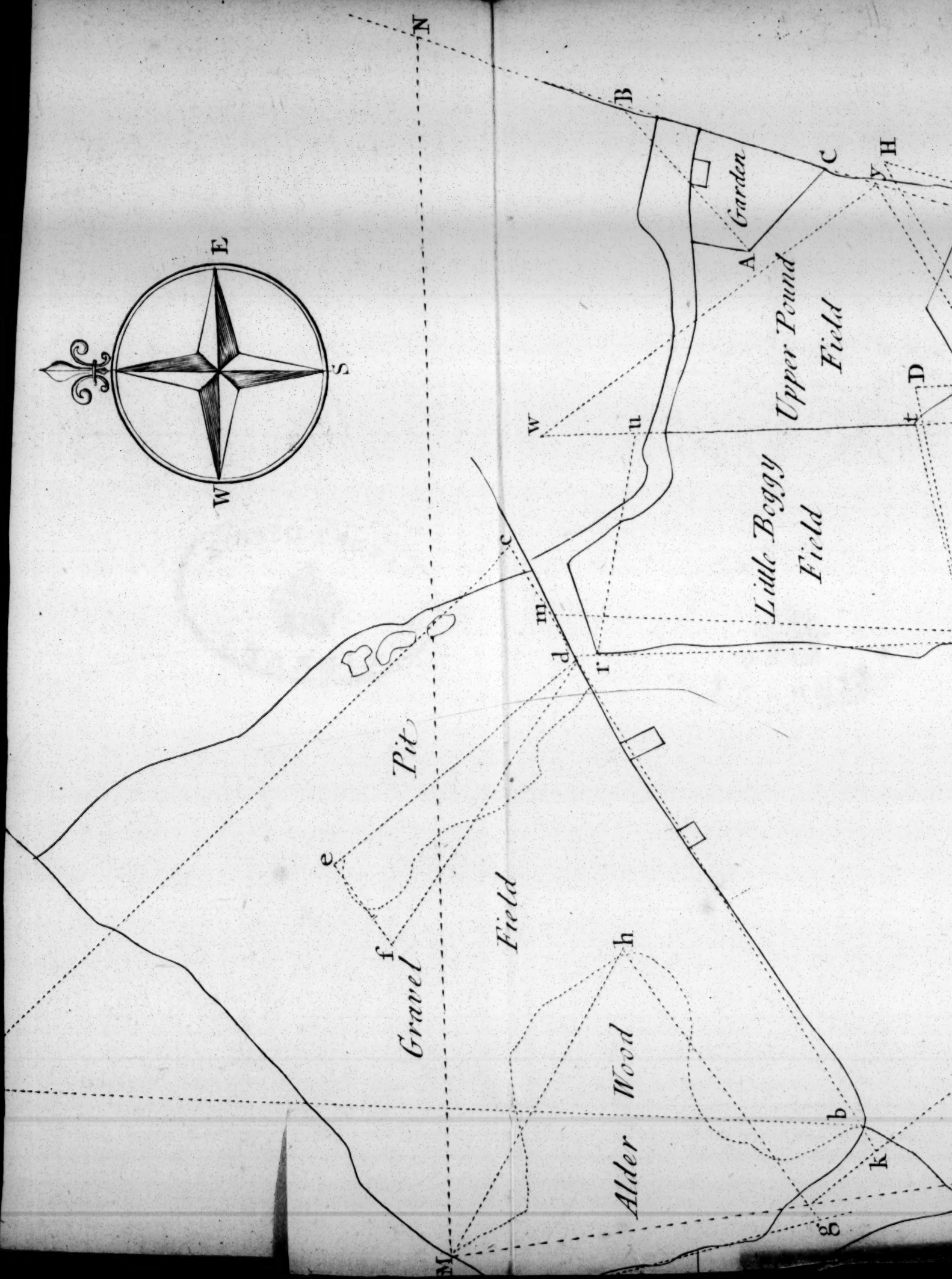
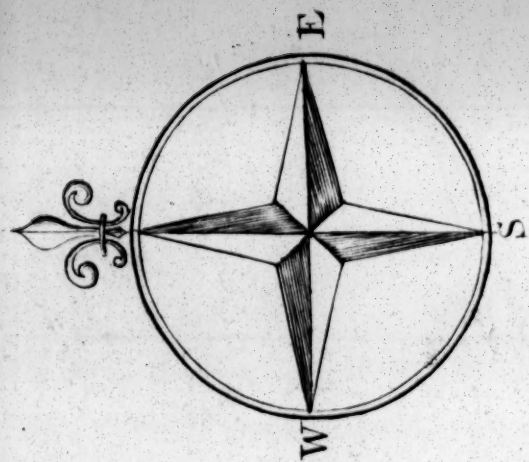
The Lord

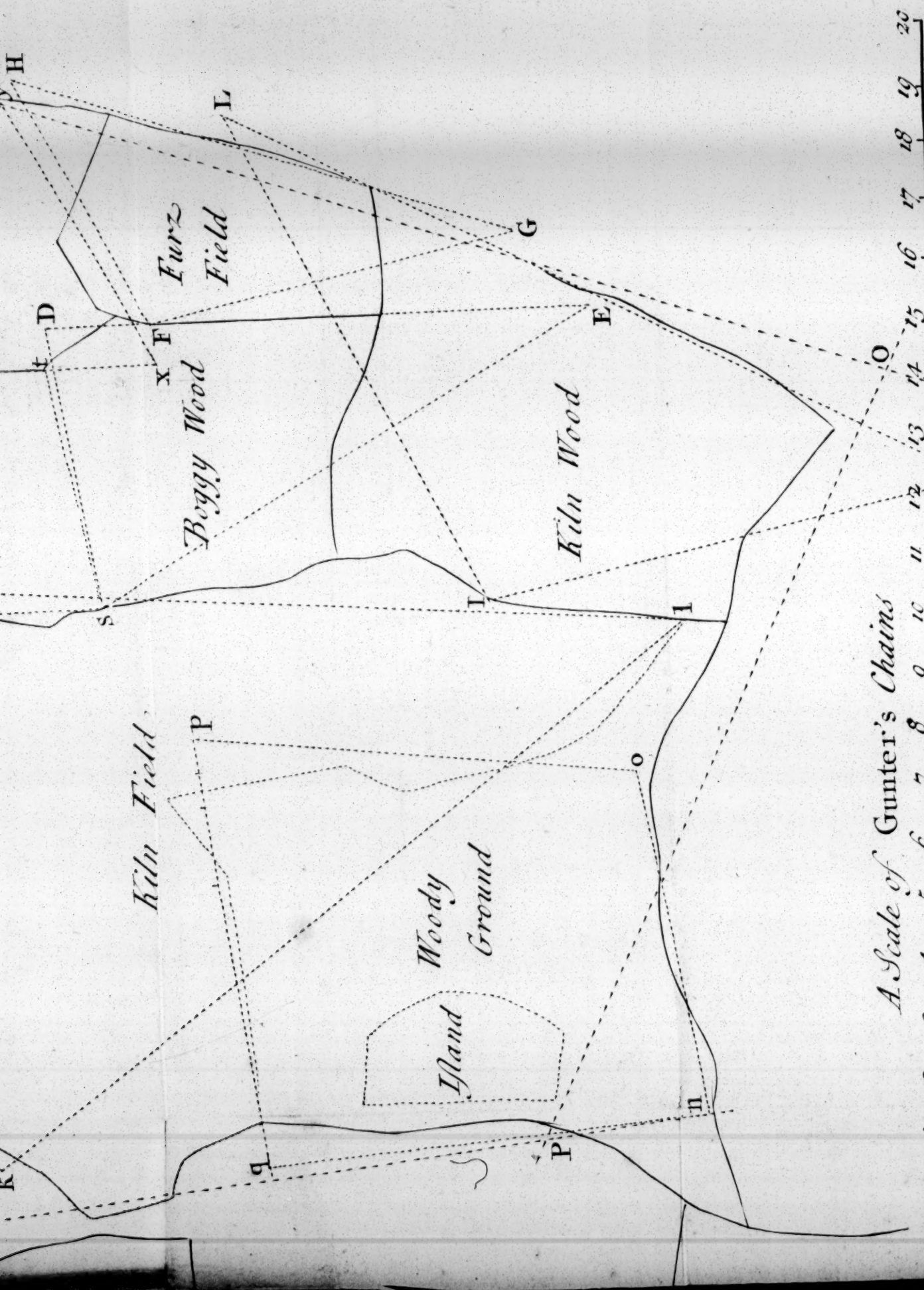
Wm Wary's Land.





Plotted by a Scale of 3 Chains or 12 Poles to an Inch





A Scale of Gunter's Chains

